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DISTANT EKOs

The Kuiper Belt Electronic Newsletter

Edited by: Joel Wm. Parker

ekonews@boulder.swri.edu www.boulder.swri.edu/ekonews

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NEWS & ANNOUNCEMENTS

There were 2 new TNO discoveries announced since the previous issue of *Distant EKOs*:

2011 HD103, 2011 HF103

and 3 new Centaur/SDO discoveries:

2011 QF99, 2013 EK73, 2013 EZ27

Deleted object:

2013 CE88

Current number of TNOs: 1260 (including Pluto)
Current number of Centaurs/SDOs: 373
Current number of Neptune Trojans: 9

Out of a total of 1642 objects:

649 have measurements from only one opposition
633 of those have had no measurements for more than a year
325 of those have arcs shorter than 10 days

(for more details, see: `http://www.boulder.swri.edu/ekonews/objects/recov_stats.jpg`)

PAPERS ACCEPTED TO JOURNALS

Small Particles in Pluto's Environment: Effects of the Solar Radiation Pressure

P.M. Pires dos Santos[1], S.M. Giuliatti Winter[1], R. Sfair[1] and D.C. Mourão[1]

[1] UNESP - Univ. Estadual Paulista, Campus de Guaratinguetá, Brazil

Impacts of micrometeoroids on the surfaces of the plutonian small satellites Nix and Hydra can generate dust particles. Even in this region so far from the Sun these tiny ejected particles are under the effects of the solar radiation pressure.

In this work, we investigate the orbital evolution of the escaping ejecta from both the small satellites under the effects of the radiation pressure combined with the gravitational effects of Pluto, Charon, Nix and Hydra. The mass production rate of micron-sized dust particles generated by micrometeoroids hitting the satellites is obtained, and numerical simulations are performed to derive the lifetime of the ejecta. These pieces of information allow us to estimate the optical depth of a putative ring, which extends from the orbits of Nix to Hydra.

The ejected particles, between the orbits of Nix and Hydra, form a wide ring of about 16,000 km. Collisions with the massive bodies and escape from the system are mainly determined by the effects of the solar radiation pressure. This is an important loss mechanism, removing 30 per cent of the initial set of 1 μm-sized particles in 1 yr. The surviving particles form a ring too faint to be detectable with the derived maximum optical depth of 4×10^{-11}.

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Pluto's Seasons: New Predictions for New Horizons

L.A. Young[1]

[1] Southwest Research Institute, 1050 Walnut St., Suite 300, Boulder, CO 80302, USA

Since the last Pluto volatile transport models were published in 1996, we have (1) new stellar occultation data from 2002 and 2006-2012 that show roughly twice the pressure as the first definitive occultation from 1988, (2) new information about the surface properties of Pluto, (3) a spacecraft due to arrive at Pluto in 2015, and (4) a new volatile transport model that is rapid enough to allow a large parameter-space search. Such a parameter-space search coarsely constrained by occultation results reveals three broad solutions: a high-thermal inertia, large volatile inventory solution with permanent northern volatiles (PNVs; using the rotational north pole convention); a lower thermal-inertia, smaller volatile inventory solution with exchanges of volatiles between hemispheres and a pressure plateau beyond 2015 (exchange with pressure plateau, EPP); and solutions with still smaller volatile inventories, with exchanges of volatiles between hemispheres and an early collapse of the atmosphere prior to 2015 (exchange with early collapse, EEC). PNV and EPP are favored by stellar occultation data, but EEC cannot yet be definitively ruled out without more atmospheric modeling or additional occultation observations and analysis.

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For preprints, contact `layoung@boulder.swri.edu`
and available online at: `http://arxiv.org/abs/1210.7778`

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On the Possible Noble Gas Deficiency of Pluto's Atmosphere

Olivier Mousis[1,2], Jonathan I. Lunine[3], Kathleen E. Mandt[4], Eric Schindhelm[5], Harold A. Weaver[6], S. Alan Stern[5], J. Hunter Waite[4], Randy Gladstone[4], and Audrey Moudens[7]

[1] Université de Franche-Comté, Institut UTINAM, CNRS/INSU, UMR 6213, Besançon Cedex, France

[2] Université de Toulouse; UPS-OMP; CNRS-INSU; IRAP; 14 Avenue Edouard Belin, 31400 Toulouse, France

[3] Center for Radiophysics and Space Research, Space Sciences Building Cornell University, Ithaca, NY 14853, USA

[4] Space Science and Engineering Division, Southwest Research Institute, San Antonio, TX 78228, USA

[5] Southwest Research Institute, 1050 Walnut Street, Boulder, CO 8030223, USA

[6] Space Department, Johns Hopkins University Applied Physics Laboratory, 11100 Johns Hopkins Road, Laurel, MD 20723-6099, USA

[7] LERMA, Université de Cergy-Pontoise, Observatoire de Paris, ENS, UPMC, UMR 8112 du CNRS, 5 mail Gay Lussac, 95000 Cergy Pontoise Cedex, France

We use a statistical-thermodynamic model to investigate the formation and composition of noble-gas-rich clathrates on Pluto's surface. By considering an atmospheric composition close to that of today's Pluto and a broad range of surface pressures, we find that Ar, Kr and Xe can be efficiently trapped in clathrates if they formed at the surface, in a way similar to what has been proposed for Titan. The formation on Pluto of clathrates rich in noble gases could then induce a strong decrease in their atmospheric abundances relative to their initial values. A clathrate thickness of order of a few centimeters globally averaged on the planet is enough to trap all Ar, Kr and Xe if these noble gases were in protosolar proportions in Pluto's early atmosphere. Because atmospheric escape over an extended period of time (millions of years) should lead to a noble gas abundance that either remains constant or increases with time, we find that a potential depletion of Ar, Kr and Xe in the atmosphere would best be explained by their trapping in clathrates. A key observational test is the measurement of Ar since the Alice UV spectrometer aboard the New Horizons spacecraft will be sensitive enough to detect its abundance $\sim$10 times smaller than in the case considered here.

To appear in: Icarus
For preprints, contact `olivier.mousis@obs-besancon.fr`
or on the web at `http://arxiv.org/abs/1303.4595`

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ODIN: A New Model and Ephemeris for the Pluto System

L. Beauvalet[1], V. Robert[1,2], V. Lainey[1], J.-E. Arlot[1], and F. Colas[1]

[1] Institut de Mécanique Céleste et de Calcul des Éphémérides - Observatoire de Paris, UMR 8028 CNRS, Université Pierre et Marie Curie, Université Lille 1, 77 avenue Denfert Rochereau, 75014 Paris, France

[2] Institut Polytechnique des Sciences Avancées IPSA, 7-9 rue Maurice Grandcoing, 94200 Ivry-sur-Seine, France

Because of Pluto's distance from the Sun, the Pluto system has not yet completed a revolution since its discovery, hence an uncertain heliocentric distance. In this paper, we present the fitting of our dynamical model ODIN (Orbite, Dynamique et Intégration Numérique) to observations. The small satellites P4 and P5 are not taken into account. We fitted our model to the measured absolute coordinates (RA, DEC) of Pluto, and to the measured positions of the satellites relative to Pluto. The masses we found for the bodies of the system are consistent with those of previous studies. Yet the masses of the small satellites Nix and Hydra are artificially constrained by the number of observations of Charon. The best way to improve the determination of their masses would be to use observations of P4 and P5, but there are still not enough published observations. Concerning the heliocentric

distance of the system, we compared the value we obtained using ODIN and those of other models. The difference between the models far exceeds the uncertainty needed (about 1000 km) for the mission New Horizons. A new astrometric reduction of old photographic plates may be an efficient way to constrain this distance. The ephemeris for Pluto's satellites is available on the web page of the IMCCE at `http://www.imcce.fr/hosted_sites/saimirror/nssreq9hf.htm`. The complete version of the ephemeris is available as a SPICE kernel at `http://www.imcce.fr/ beauvalet`.

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Photometry and Taxonomy of TNOs and Centaurs in Support of a Herschel Key Program

D. Perna[1], E. Dotto[2], M.A. Barucci[1], E. Mazzotta Epifani[3], E. Vilenius[4], M. Dall'Ora[3], S. Fornasier[1,5], and T.G. Müller[4]

[1] LESIA – Observatoire de Paris, CNRS, UPMC Univ. Paris 06, Univ. Paris-Diderot, 5 place J. Janssen, 92195, Meudon, France

[2] INAF – Osservatorio Astronomico di Roma, Via Frascati 33, 00040 Monte Porzio Catone (Roma), Italy

[3] INAF – Osservatorio Astronomico di Capodimonte, Salita Moiariello 16, 80131 Napoli, Italy

[4] Max-Planck-Institut für extraterrestrische Physik, Postfach 1312, Giessenbachstr., 85741 Garching, Germany

[5] Univ. Paris Diderot, Sorbonne Paris Cité, 4 rue Elsa Morante, 75205, Paris, France

Context: The investigation of Centaurs and trans-Neptunian objects (TNOs) provides essential information about the early conditions and evolution of the outer solar system. The radiometric technique combines measurements in the visible and thermal infrared; with these one can estimate the size and albedo of Centaurs and TNOs.

Aims: Our aim is to obtain visible photometry of a sample of Centaurs and TNOs, a subset of the targets of the "TNOs are cool" Key Programme at the Herschel Space Observatory.

Methods: We carried out visible photometry of Centaurs and TNOs, making use of the DOLORES instrument at the Telescopio Nazionale Galileo (TNG, La Palma, Spain).

Results: We report photometric observations of 20 objects and present the computed absolute magnitudes. We derive the taxonomy of our targets (nine are classified for the first time, the results for five objects agree with the literature, the other targets are tentatively classified based on incomplete datasets) and combine the results with the literature, searching for correlations between taxonomy and dynamics. We look for comet-like activity in our Centaur sample, including (248835) 2006 SX368, which was previously described as active.

Conclusions: We provide an accurate determination of the absolute magnitude and of the relative error for each of our targets. These values can be readily used in combination with thermal infrared data. The surface of TNO (65489) Ceto seems to be heterogeneous. Our results seem to support an evolutionary origin for the color dichotomy of Centaurs, and the occurrence of a strong mixing after the TNO formation. No evident cometary activity is detected around the five Centaurs in our sample; assuming that an unresolved coma is present around (248835) 2006 SX368, we use the "photometric model" to derive the possible dust production rate, finding that Q_{dust} is in the range 1–31 kg/s.

To appear in: Astronomy & Astrophysics

For preprints, contact `davide.perna@obspm.fr`

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TNOs are Cool: A Survey of the Trans-Neptunian Region. VIII. Combined Herschel PACS and SPIRE Observations of 9 Bright Targets at 70–500 μm

S. Fornasier [1,2], E. Lellouch[1], T. Müller[3], P. Santos-Sanz[1,4], P. Panuzzo[5,6], C. Kiss[7], T. Lim[8], M. Mommert[9], D. Bockelée-Morvan[1], E. Vilenius[3], J. Stansberry[10], G.P. Tozzi[11], S. Mottola[9], A. Delsanti[1,12], J. Crovisier[1], R. Duffard[4], F. Henry[1], P. Lacerda[13], A. Barucci[1], and A. Gicquel[1]

[1]LESIA, Observatoire de Paris, CNRS, UPMC Univ Paris 06, Univ. Paris-Diderot, 5 Place J. Janssen, 5 place Jules Janssen, 92195 Meudon Pricipal Cedex, France

[2] Univ Paris Diderot, Sorbonne Paris Cité, 4 rue Elsa Morante, 75205 Paris Cedex 13, France

[3] Max-Planck-Institut für extraterrestrische Physik (MPE), Giessenbachstrasse, 85748 Garching, Germany

[4] Instituto de Astrofísica de Andalucía (CSIC), Glorieta de la Astronomía s/n, 18008 Granada, Spain

[5] GEPI, Observatoire de Paris, CNRS, Univ. Paris Diderot, Place Jules Janssen, 92195 Meudon Pricipal Cedex, France

[6] CEA, Laboratoire AIM, Irfu/SAp, 91191 Gif-sur-Yvette, France

[7] Konkoly Observatory, Research Centre for Astronomy and Earth Sciences, Hungarian Academy of Sciences, Konkoly Thege 15-17, H-1121 Budapest, Hungary

[8] Space Science and Technology Department, Science and Technology Facilities Council, Rutherford Appleton Laboratory, Harwell Science and Innovation Campus, Didcot, Oxon UK, OX11 0QX, UK

[9] Institute of Planetary Research, DLR, Rutherfordstrasse 2, 12489 Berlin, Germany

[10] The University of Arizona, Tucson AZ 85721, USA

[11] INAF–Osservatorio Astrofisico di Arcetri, Largo E. Fermi 5, 50125, Firenze, Italy

[12] Aix Marseille Université, CNRS, LAM (Laboratoire d'Astrophysique de Marseille) UMR 7326, 38 rue Frédéric Joliot-Curie, 13388 Marseille, France

[13] Astrophysics Research Centre, Queen's University Belfast, Belfast BT7 1NN

Transneptunian Objects (TNOs) are bodies populating the Kuiper Belt and they are believed to retain the most pristine and least altered material of the Solar System. The Herschel Open Time Key Program entitled "TNOs are Cool: A survey of the Transneptunian Region" has been awarded 373 hours to investigate the albedo, size distribution and thermal properties of TNOs and Centaurs. Here we focus on the brightest targets observed by both the PACS and SPIRE multiband photometers: the dwarf planet Haumea, 6 TNOs (Huya, Orcus, Quaoar, Salacia, 2002 UX25, and 2002 TC302), and two Centaurs (Chiron and Chariklo). Flux densities are derived from PACS and SPIRE instruments using optimised data reduction methods. The spectral energy distribution obtained with the Herschel PACS and SPIRE instruments over 6 bands (centered at 70, 100, 160, 250, 350 and 500 μm), with Spitzer-MIPS at 23.7 and 71.4 μm, and with WISE at 11.6 and 22.1 μm in the case of 10199 Chariklo, has been modeled with the NEATM thermal model in order to derive the albedo, diameter and beaming factor. For the Centaurs Chiron and Chariklo, and for the 1000 km sized Orcus and Quaoar, a thermophysical model was also run to better constrain their thermal properties. We derive the size, albedo, and thermal properties, including thermal inertia and surface emissivity, for the 9 TNOs and Centaurs. Several targets show a significant decrease of their spectral emissivity longward of $\sim$300 μm and especially at 500 μm. Using our size estimations and the mass values available in the literature, we also derive the bulk densities for the binaries Quaoar/Weywot ($2.18^{+0.43}_{-0.36}$ g/cm^3), Orcus/Vanth ($1.53^{+0.15}_{-0.13}$ g/cm^3), and Salacia/Actea ($1.29^{+0.29}_{-0.23}$ g/cm^3). Quaoar's density is similar to that of the other dwarf planets Pluto and Haumea, and its value implies high contents of refractory materials mixed with ices.

To appear in: Astronomy and Astrophysics

For preprints, contact sonia.fornasier@obspm.fr

On the Size, Shape, and Density of Dwarf Planet Makemake

M.E. Brown[1]

[1] Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena, CA 91125, USA

A recent stellar occultation by dwarf planet Makemake provided an excellent opportunity to measure the size and shape of one of the largest objects in the Kuiper belt. The analysis of these results provided what were reported to be precise measurements of the lengths of the projected axes, the albedo, and even the density of Makemake, but these results were, in part, derived from qualitative arguments. We reanalyzed the occultation timing data using a quantitative statistical description, and, in general, find the previously reported results on the shape of Makemake to be unjustified. In our solution, in which we use our inference from photometric data that Makemake is being viewed nearly pole-on, we find a 1σ upper limit to the projected elongation of Makemake of 1.02, with measured equatorial diameter of 1434±14 km and a projected polar diameter of 1422±14 km, yielding an albedo of $0.81^{+0.01}_{-0.02}$. If we remove the external constraint on the pole position of Makemake, we find instead a 1σ upper limit to the elongation of 1.06, with a measured equatorial diameter of 1434^{+48}_{-18} km and a projected polar diameter of 1420^{+18}_{-24} km, yielding an albedo of $0.81^{+0.03}_{-0.05}$. Critically, we find that the reported measurement of the density of Makemake was based on the misapplication of the volatile retention models. A corrected analysis shows that the occultation measurements provide no meaningful constraint on the density of Makemake.

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Preprints available on the web at `http://www.gps.caltech.edu/~mbrown/papers/pubs.html`

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Do Centaurs Preserve Their Source Inclinations?

K. Volk[1] **and R. Malhotra**[1]

[1] Lunar and Planetary Laboratory, The University of Arizona, Tucson, AZ 85721, USA

The Centaurs are a population of small, planet-crossing objects in the outer solar system. They are dynamically short-lived and represent the transition population between the Kuiper belt and the Jupiter family short-period comets. Dynamical models and observations of the physical properties of the Centaurs indicate that they may have multiple source populations in the trans-Neptunian region. It has been suggested that the inclination distribution of the Centaurs may be useful in distinguishing amongst these source regions. The Centaurs, however, undergo many close encounters with the giant planets during their orbital evolution; here we show that these encounters can substantially determine the inclination distribution of the Centaurs. Almost any plausible initial inclination distribution of a Kuiper belt source results in Centaurs having inclinations peaked near $10 - 20°$. Our studies also find that the Kuiper belt is an extremely unlikely source of the retrograde Centaur that has been observed.

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For preprints, contact `kvolk@lpl.arizona.edu`
or on the web at `http://arxiv.org/abs/1211.2774`
and `http://www.sciencedirect.com/science/article/pii/S0019103513000766`

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The Production of Craters on the Mid-sized Saturnian Satellites by Centaur Objects

R.P. Di Sisto[1,2] and M. Zanardi[2]

[1] Facultad de Ciencias Astronómicas y Geofísicas, Universidad Nacional de La Plata, Argentina

[2] Instituto de Astrofísica de La Plata, CCT La Plata-CONICET-UNLP. Paseo del Bosque S/N (1900), La Plata, Argentina

The Saturnian satellite system has been observed in detail by the Cassini-Huygens mission. These satellites present different surface features, including impact craters caused by small objects probably coming from the trans-Neptunian region. In this paper we calculate the production of craters on the mid-sized Saturnian satellites produced by Centaurs from the scattered disk (SD) and plutinos in order to determine this contribution, and we compare our estimations with the Cassini observations. We used a method developed in a previous paper that uses a numerical investigation of the dynamical evolution of Centaur objects to calculate the production of craters. We used a size-frequency distribution (SFD) of scattered disk objects (SDOs) as a power law with a break at diameters $d = 60$ km considering two cases for the differential power-law index: $s_2 = 2.5$ and $s_2 = 3.5$ for $d < 60$ km. We calculated the number of craters, the greatest crater produced by Centaurs from the SD and plutinos, and the present cratering rate on each of the mid-sized satellites, for both cases of the SFD of SDOs considered. The contribution of plutinos is negligible compared to SDOs. From our calculations and the comparison with observations we note that the calculated number of craters for $s_2 = 3.5$ is in general nearer the observed number. However, in general for smaller craters, the observed number is less than the calculated one. This trend can be explained by at least two mechanisms. One the one hand, this could be caused by an erasing process that gradually buries the craters, which does not affect large craters. On the other hand, the comparison of the calculated and observed crater size-frequency distribution for different size ranges implies that for $d < 60$ km, the SFD of SDOs is consistent with the assumed index $s_2 = 3.5$, for $d > 0.2 - 1.4$ km and for $d < 0.2 - 1.4$ km, it is consistent with $s_2 = 2.5$. Then in the range $d < 0.2 - 1.4$ km, the SFD of SDOs could have a new break. This change of slope could explain the reduction of small craters, at least for some cases. We found a good agreement when comparing our results with observations. However, independent determination of surface ages and geological processes are needed to determine if there is a new break on the SFD of SDOs, if there is a planetocentric source of craters in the Saturnian system, and which craters are primordial.

To appear in: Astronomy and Astrophysics

For preprints, contact romina@fcaglp.unlp.edu.ar

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UltraCarbonaceous Antarctic Micrometeorites, Probing the Solar System Beyond the Nitrogen Snow-Line

E. Dartois[1], C. Engrand[2], R. Brunetto[1], J. Duprat[2], T. Pino[3], E. Quirico[4], L. Remusat[5], N. Bardin[2], G. Briani[2], S. Mostefaoui[5], G. Morinaud[1], B. Crane[1], N. Szwec[1], L. Delauche[2], F. Jamme[6], Ch. Sandt[6], and P. Dumas[6].

[1] Institut d'Astrophysique Spatiale (IAS), Université Paris-Sud, UMR 8617-CNRS INSU, Bât 121, F-91405 Orsay, France

[2] Centre de Spectrométrie Nucléaire et de Spectrométrie de Masse (CSNSM), Université Paris-Sud, UMR 8609-CNRS/IN2P3, F-91405 Orsay, France

[3] Institut des Sciences Moléculaires d'Orsay (ISMO), UMR 8214-CNRS Université Paris Sud, bât.210, F-91405 Orsay

Cedex, France
[4] UJF-Grenoble 1/CNRS-INSU, Institut de Planétologie et dAstrophysique de Grenoble (IPAG), UMR 5274-CNRS INSU, Grenoble F-38041, France
[5] Laboratoire de Minéralogie et Cosmochimie du Muséum (LMCM), UMR 7202-CNRS INSU, Muséum National d'Histoire Naturelle, 57 Rue Cuvier, 75231 Paris Cedex 05, France
[6] Synchrotron SOLEIL, L'orme des Merisiers, BP 48, Saint Aubin, F-91192 Gif sur Yvette, France

The current solar system architecture is a heritage of the protoplanetary disk that surrounded the young sun, 4.56 Gy ago. Primitive extraterrestrial objects provide means to trace back the primordial composition and radial distribution of matter in this disk. Here, we present a combined micro-IR, Raman, chemical and isotopic study of two ultra-carbonaceous micrometeorites recovered from Antarctica (UCAMMs). This study reveals particles containing an unusually high nitrogen- and deuterium- rich organic matter analogous to a polyaromatic hydrogenated carbon nitride, characterised by nitrogen concentration with bulk atomic N/C ratios of 0.05 and 0.12 (locally exceeding 0.15). We propose that such nitrogen-rich carbonaceous material can be formed by energetic irradiations of nitrogen-rich ices in very low temperature regions of the solar system. Such conditions are encountered at the surface of small objects beyond the trans-Neptunian region. UCAMMs provide unique insights on physico-chemical processes that occurred beyond the nitrogen snow-line, revealing organic material from the extreme outer regions of the solar system that cannot be investigated by remote sensing methods.

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For preprints, contact emmanuel.dartois@ias.u-psud.fr , cecile.engrand@csnsm.in2p3.fr

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Ultraviolet and Infrared Spectra of Electron-Bombarded Solid Nitrogen and Methane Diluted in Solid Nitrogen

Yu-Jong Wu[1,3], Hui-Fen Chen[2], Shiang-Jiun Chuang[1], and Tzu-Ping Huang[1]

[1] National Synchrotron Radiation Research Center, No. 101, Hsin-Ann Road, Hsinchu Science Park, Hsinchu 30076, Taiwan
[2] 2 Department of Medical and Applied Chemistry, Kaohsiung Medical University, 100, Shih-Chuan 1 st Road, Kaohsiung 80708, Taiwan

The infrared (IR) and ultraviolet (UV) absorption spectra of pure solid N_2 and CH_4 diluted in solid N_2 (1/100) irradiated with energetic electrons at 10 K were obtained. The IR absorption measurements of the electron-bombarded pure N_2 solid reveal the formation of N_3 and N_3^+ , which was confirmed by the observed electronic transitions $A^2\Sigma_u{}^+ \leftarrow X^2\Pi_g$ of N_3 and $A^3\Pi_u \leftarrow X^3\Sigma_g{}^-$ of N_3^+ . In the case of N_2 ice containing a small proportion of CH_4, we have identified the products of irradiated CH_4/N_2 ice, including N_3, C_nN ($n = 1 - 3$), CN_2, $(CN)_2$, CH_3N, HCN_2, HC_2N, $C(NH)_2$, HNC, HCN, CH_3, C_2H, C_2H_2, CN^-, NH_3^+ , and HC_3N^+. UV absorption measurement of the ice sample was carried out and the possible carriers associated with the observed absorption bands were assigned and discussed.

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PAPERS RECENTLY SUBMITTED TO JOURNALS

Size, Shape, Albedo, Density and Atmospheric Limit of Transneptunian Object (50000) Quaoar from Multi-chord Stellar Occultations

F. Braga-Ribas [1,2], B. Sicardy[2,3], J.L. Ortiz [4], E. Lellouch [2], G. Tancredi[5], J. Lecacheux[2], R. Vieira-Martins[1,6,7], J.I.B. Camargo[1], M. Assafin[7], R. Behrend[8], F. Vachier[6], N. Morales[4], A. Maury[9], M. Emilio[10], A. Amorim[11], E. Unda-Sanzana[12], S. Roland[5], S. Bruzzone[5], L.A. Almeida[13], C.V. Rodrigues[13], C. Jacques[14], R. Gil-Hutton[15], L. Vanzi[16], A.C. Milone[13], W. Schoenell[11,4], R. Salvo[5], L. Almenares[5], E. Jehin[17], J. Manfroid[17], S. Sposetti[18], P. Tanga[19], A. Klotz[20], E. Frappa[21], P. Cacella[22], J.P. Colque[12], C. Neves[10], E. M. Alvarez[23], M. Gillon[17], E. Pimentel[14], B. Giacchini[14], F. Colas[6], F. Roques[2], T. Widemann[2], V.S. Magalhães[13], A. Thirouin[4], R. Duffard[4], R. Leiva[16], I. Toledo[24], J. Capeche[5], W. Beisker[25], J. Pollock[26], C. E. Cedeño Montaña[13], K. Ivarsen[27], D. Reichart[27], J. Haislip[27], and A. Lacluyze[27]

[1] Observatório Nacional, Rio de Janeiro, Brazil

[2] Observatoire de Paris, LESIA, Meudon, France

[3] Université Pierre et Marie Curie, Paris, France

[4] Instituto de Astrofísica de Andalucía - CSIC, Granada, Spain

[5] Observatorio Astronomico Los Molinos, Uruguay

[6] Observatoire de Paris, IMCCE, Paris, France

[7] Observatório do Valongo / UFRJ, Rio de Janeiro, Brazil

[8] Observatoire de Genève, Switzerland

[9] San Pedro de Atacama Celestial Explorations, San Pedro de Atacama, Chile

[10] Universidade Estadual de Ponta Grossa, Ponta Grossa, Brazil

[11] Universidade Federal de Santa Catarina, Florianópolis, Brazil

[12]Unidad de Astronomía, Universidad de Antofagasta, Antofagasta, Chile

[13] Instituto Nacional de Pesquisas Espaciais, DAS, São José dos Campos, Brazil

[14] Centro de Estudos Astronômicos de Minas Gerais (CEAMIG), Belo Horizonte, Brazil

[15] Complejo Astronómico El Leoncito & San Juan National University, Argentina

[16] Department of Electrical Engineering and Center of Astro-Engineering, Pontificia Universidad Católica de Chile, Santiago, Chile

[17] Institut d'Astrophysique de l'Université de Liége, Belgium

[18] Gnosca Observatory, Switzerland

[19] Laboratoire Lagrange, Université de Sophia Antipolis, Observatoire de la Côte d'Azur, CNRS UMS7293

[20] Université de Toulouse, UPS-OMP, IRAP, France

[21] Euraster, 1B cours J. Bouchard, St-Etienne, France

[22] Rede de Astronomia Observacional, Brasilia, Brazil

[23] Observatorio Los Algarrobos, Salto, Uruguay

[24] Joint ALMA Observatory, Alonso de Córdova 3107, Vitacura, Santiago, Chile

[25] International Occultation Timing Association - European Section, Munich, Germany

[26] Department of Physics and Astronomy, Appalachian State Univ., Boone, NC 28608, USA

[27] Physics and Astronomy Department, University of North Carolina, Chapel Hill, USA

Submitted to: The Astrophysical Journal

For preprints, contact ribas@on.br

THESES

Exploration of the Trans-Neptunian Objects by the Stellar Occultation Method: Predictions, Observations, Quaoar and the First Results

Felipe Braga-Ribas[1,2]

[1] Observatório Nacional / MCTI, Rua General José Cristino, 77, Rio de Janeiro, RJ, Brazil

[2] Observatoire de Paris - Meudon / LESIA, 11 Av. Marcelin Berthelot, Meudon, France

Transneptunian objects (TNOs) are fossils of the Solar System beyond Neptune. Over 1200 TNOs have been found since 1992, and among them we find dwarf-planets such as Pluto, Makemake and Eris. The dynamics, internal and surface composition, size and mass distribution may have information about the early ages and evolution of the Solar System.

Photometry, spectroscopic, thermal (far infra-red) give information about their rotational period, surface composition, size and albedo estimations.

Nevertheless, due to their distance (greater than 30 Astronomical Units) and their sizes, we do not have the necessary technology to directly measure their size and detect possible atmospheres, as their angular sizes are smaller than a 50 miliarcseconds (mas).

The stellar occultation technique consists of observing the transit of a TNO in front of a star. The precise duration of the event, observed from several different sites, allows to deduce their size and shape with kilometre accuracy. So, precise determination of their albedo can be derived, and for those bodies that have their mass deduced from its satellite orbit, precise determination of their densities is allowed. Besides, tenuous atmospheres at the nanobar level, can be detected as they promote an attenuation of the star light right before and after the occultation.

In this work it is described (1) the prediction method applied to more then fifty TNOs, with accuracy of about 30 mas, (2) the world-wide campaigns with tens of professional and amateurs observatories, (3) the observation, analysis, and interpretation of the observed occultation by Quaoar and other large transneptunian objects.

Since 2009, fourteen occultations by TNOs were already observed, twelve by the Paris/Rio consortium. In addition to the detailed discussion about the Quaoar events, a compilation of all the other results comprising as size, shape, albedo, density and atmosphere, obtained from TNO stellar occultations is presented. In particular occultations by Eris, Makemake, 2003 AZ_{84}, Varuna and Sedna, all of which are new.

We present constraints over size, shape, albedo of these bodies, and also upper limits on possible atmospheres up to the nanobar level.

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Address as of May, 2013: Observatório Nacional / MCTI, Rua General José Cristino, 77, Rio de Janeiro, RJ, Brazil, CEP: 20921-400.

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CONFERENCE INFORMATION

The Pluto System on the Eve of Exploration by New Horizons: Perspectives And Predictions

22-26 July 2013
Johns Hopkins Applied Physics Laboratory
Laurel, Maryland USA
`http://plutoscience.jhuapl.edu`

The planning for the Pluto-2013 Conference is proceeding on schedule.

Given the importance of this meeting for optimizing the scientific return from NASA's New Horizons mission, we expect NASA to allow participation by its civil servants, at least those already involved in KBO research. And, as usual for scientific conferences, researchers can use their grant money to fund their participation in this conference.

The deadline for oral abstract submissions passed on April 15th (111 abstracts were received), but poster abstracts can still be submitted through June 15th. We encourage you to consider submitting an abstract, and to register for the meeting.

Both registration and abstract submission are available for the Pluto 2013 conference at: `http://plutoscience.jhuapl.edu`

Abstract submission information:
Abstracts are solicited on all facets of the Pluto system including origins, interiors, surfaces, compositions, atmospheres, satellites, plasma, and context in the Kuiper Belt. Abstracts should be in PDF Format. Abstracts are limited to two pages but any shorter length is also welcome. Abstracts must be uploaded to the conference website; please create a user account using the "Request an Account" form.

Deadlines:
Early Bird Registration Deadline: May 31, 2013
Late Abstract Deadline (posters): June 15, 2013
Reception: July 21, 2013
Meeting Dates: July 22-26, 2013

The meeting will be held at The Johns Hopkins University Applied Physics Laboratory in Laurel, Maryland, USA. A special issue of Icarus is planned to publish new results and prediction papers in advance of the New Horizons flyby.

Alan Stern (Program Committee Chair)
Hal Weaver (Local Organizing Committee Chair)

The *Distant EKOs* Newsletter is dedicated to provide researchers with easy and rapid access to current work regarding the Kuiper belt (observational and theoretical studies), directly related objects (e.g., Pluto, Centaurs), and other areas of study when explicitly applied to the Kuiper belt.

We accept submissions for the following sections:
⋆ Abstracts of accepted papers
⋆ Titles of submitted (but not yet accepted) papers and conference articles
⋆ Thesis abstracts
⋆ Short articles, announcements, or editorials
⋆ Status reports of on-going programs
⋆ Requests for collaboration or observing coordination
⋆ Table of contents/outlines of books
⋆ Announcements for conferences
⋆ Job advertisements
⋆ General news items deemed of interest to the Kuiper belt community

A LaTeX template for submissions is appended to each issue of the newsletter, and is sent out regularly to the e-mail distribution list. Please use that template, and send your submission to:

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Recent and back issues of the newsletter are archived there in various formats. The web pages also contain other related information and links.

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